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# BERSEEM OR EGYPTIAN CLOVER

(*Trifolium alexandrinum*)

A PRELIMINARY REPORT

P. B. KENNEDY AND W. W. MACKIE

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BY P. B. KENNEDY AND W. W. MACKIE

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## ACKNOWLEDGMENTS

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## INTRODUCTION\*

The purpose of this bulletin is to add to the series of publications† already issued by the College of Agriculture dealing with leguminous crops for human food, for forage and for use in maintaining the fertility of the soils of California.

Berseem or Egyptian Clover, *Trifolium alexandrinum* L., promises to be a valuable leguminous crop for winter growing under irrigation in regions with a climate similar to that of the Imperial Valley of California. It is not expected that it will compete with alfalfa as the basic forage crop but rather as a supplementary crop for certain soils and conditions for which alfalfa is unsuited, or as a rapid growing short rotation crop in association with sorghum, cotton or truck crops. Berseem will grow in winter when alfalfa is dormant, so that it should prove valuable to the dairyman in producing a succulent feed for soiling or pasturage. As it is an annual plant of extraordinarily rapid growth, with succulent stems, abundant leaves and readily decomposable roots, it lends itself admirably for use on high-priced lands that must produce a maximum seasonal production without losing their fertility.

Berseem occupies an important rôle in the agriculture of Egypt where it is the foundation of the dairy and beef stock industry. Without the use of berseem or some leguminous crop the high yields and

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\* Reference by number is to literature cited, page 31.

† Other publications are: Bulletins 124, 224, 238, 270, 280, 292, 294, 309, 374, and Circulars 87, 93, 110, 124, 136, 189, 255, 257, of the Agricultural Experiment Station, Berkeley, California.

excellent quality of cotton could not have been maintained. Fairchild<sup>7</sup> gives an excellent account of berseem as it occurs in the Valley of the Nile where it is considered indispensable as a half-year rotation crop with cotton. The Nile silt, contrary to general belief, is not naturally a fertile soil and were it not for the foresight of the Egyptian farmer in utilizing leguminous crops extensively, the soil would lose its crop producing power (fig. 1). For centuries it has been necessary to use the manure, dried into cakes, as fuel, so that without the use of legumes the great money making crop of Egypt, cotton, could not have been maintained.



(Courtesy of U.S.D.A.)

Fig. 1.—Berseem in full flower. Bordein, Egypt.

The fact that berseem is tolerant of moderate quantities of white alkali makes it an important plant in all irrigated sections where it can be grown. We doubt whether there is any other annual forage plant in the world which can be cut four or five times in a season and produce at each cutting as large an amount of forage. In Egypt under optimum conditions, four or five cuttings are obtained, averaging more than seven tons of green forage to the acre for each cutting (figs. 2 and 3). The fifth crop is usually left to produce seed with a yield of about 360 pounds to the acre.

Aaronsohn<sup>1</sup>, referring to the use of berseem in Palestine, states that it is sown with barley in the autumn along the coast where the rainfall is as low as 14 to 16 inches. It is grown without irrigation and gives two cuttings in the spring. In very rainy seasons it yields three cuttings.

Berseem was introduced into Italy in 1907 and is recommended for the more southern arid parts not subject to frost. De Cillis<sup>6</sup> states that it always gives good results when it escapes the winter frosts. His experiments showed that the best time of seeding in Sicily was



(Courtesy of U.S.D.A.)

Fig. 2.—Camels hauling berseem to market. Egypt.



(Courtesy of U.S.D.A.)

Fig. 3.—Hauling berseem hay (*drees*). Bordein, Egypt.

towards the end of October. From three to six cuttings are obtained according to the length and severity of the midwinter resting period. Fertilizer experiments indicated that phosphates gave the best results, with potash next and nitrogen least. Gypsum had little effect on the

yield. The average yield for the season is 400 quintals of green forage to the hectare (approximately 18 tons to the acre) and in addition 264 pounds of seed to the acre.

Sornay<sup>21</sup> reports the following from experiments by Trabut:

“At the trial station of the Algerian Botanical Department, Alexandrian Clover (*berseem*) has given four crops in a year. When sown at the end of July the yield per hectare by the middle of September was 28,000 kilos, in the middle of November, 20,000, shortly after the middle of February, 30,000, and at the end of May, 25,000.” (A total of about 45 tons of green forage per acre.)

In Australia<sup>4</sup> it has been called the “Winter Lucerne” because it amply fills in the period when alfalfa is dormant. It succeeds well in those parts of the commonwealth having fairly mild winters and in the colder sections provided it is sown early enough to get well established and make a good growth before the winter sets in. It has given especially good results in the northern irrigated areas of Victoria. Results of nine years’ experiments at Roseworthy Agricultural College show that the average total yield to the acre was over 29 tons of green forage. Six cuttings are regarded as not exceptional and one farmer reports nine cuttings from heavily manured land. This was on a poultry farm where it was used as green feed at a period of the year when eggs were at a premium. He attributes his success with berseem to the heavy dressings of chicken manure that were readily available.

Mixtures of berseem with barley, oats or rye grass have also been found useful.

All experimenters and growers agree that the secret of success with this crop is to have the seed in early. It is recommended for grazing, soiling, hay, as a green manure and as an excellent plant for cleaning land and smothering weeds.

Berseem has been known to experimenters in California from the results of small trial plots for a long time. The first record we have is in 1896. It is only recently, however, that it has given promise as a field crop. This bulletin is to be regarded as a report of the results of experiments with berseem in California from which the reader must determine whether or not the crop is suitable to his conditions. Much field work remains to be done before definite recommendations can be made in regard to its place in a rotation with our established commercial crops.

## ORIGIN

Berseem, like a number of our cultivated plants, such as the horse bean (*Vicia faba*), maize (*Zea mays*), is a plant the original wild forms of which seem to have become extinct. DeCandolle<sup>5</sup> makes the following statement in regard to the origin of *Trifolium alexandrinum* L.

"This species is extensively cultivated in Egypt as fodder. Its Arab name is *bersym* or *berzun*. There is nothing to show that it has been long in use, the name does not occur in Hebrew and Armenian botanical works. The species is not wild in Egypt, but it is certainly wild in Syria and Asia Minor." He refers to Boissier<sup>3</sup> as authority for the last statement. Here we find a number of localities cited from fields or in the vicinity of towns so that it is doubtful if these plants could be regarded as being indigenous. Muschler<sup>10</sup> states that it is only known from Egypt and Cyrenaica that the true home is uncertain and adds that it is cultivated everywhere in Egypt where it is also spontaneous.

Aaronsohn<sup>1</sup> is responsible for the statement that berseem grows wild in Palestine, but does not indicate whether he means indigenous or escaped from cultivation. Fairchild<sup>7</sup> who gives an excellent account of berseem in all its phases gives Schweinfurth as authority for the statement "that no picture, bas relief, name or authentic seeds of berseem had ever been discovered in any of the tombs of Egypt." He states that "the plant has nowhere been discovered wild, but a Byzantine variety (*Trifolium alexandrinum* var. *phleoides* Boiss.) exists at Kilsali, near Smyrna, and it is probable that the plant was introduced into Egypt about the sixth century." On page 13 in a footnote we find the following: "Boissier gives *Trifolium alexandrinum* var. *phleoides* Boiss. as a variety occurring in Kilsali near Smyrna, but says nothing as to whether it is in cultivation or not." We find in Boissier "Flora Orientalis" 2-127, under habitat of this variety, "*in cultis insulae Kilsali sinus Smyrnei*" which we take to mean under cultivation. The researches of Gilbelli and Belli<sup>9</sup> regard this as a subspecies of *T. echinatum* so that it is unlikely that this variety could be regarded as the progenitor of our cultivated berseem.

From our knowledge of how localized certain species of American clovers are, we can readily understand how the indigenous form of the cultivated berseem may have become extinct especially in a region so intensively cultivated as that bordering the Mediterranean. It seems reasonable to believe that if berseem were in common cultivation by the ancient Egyptians that it would have been represented in some of their tombs or monuments.

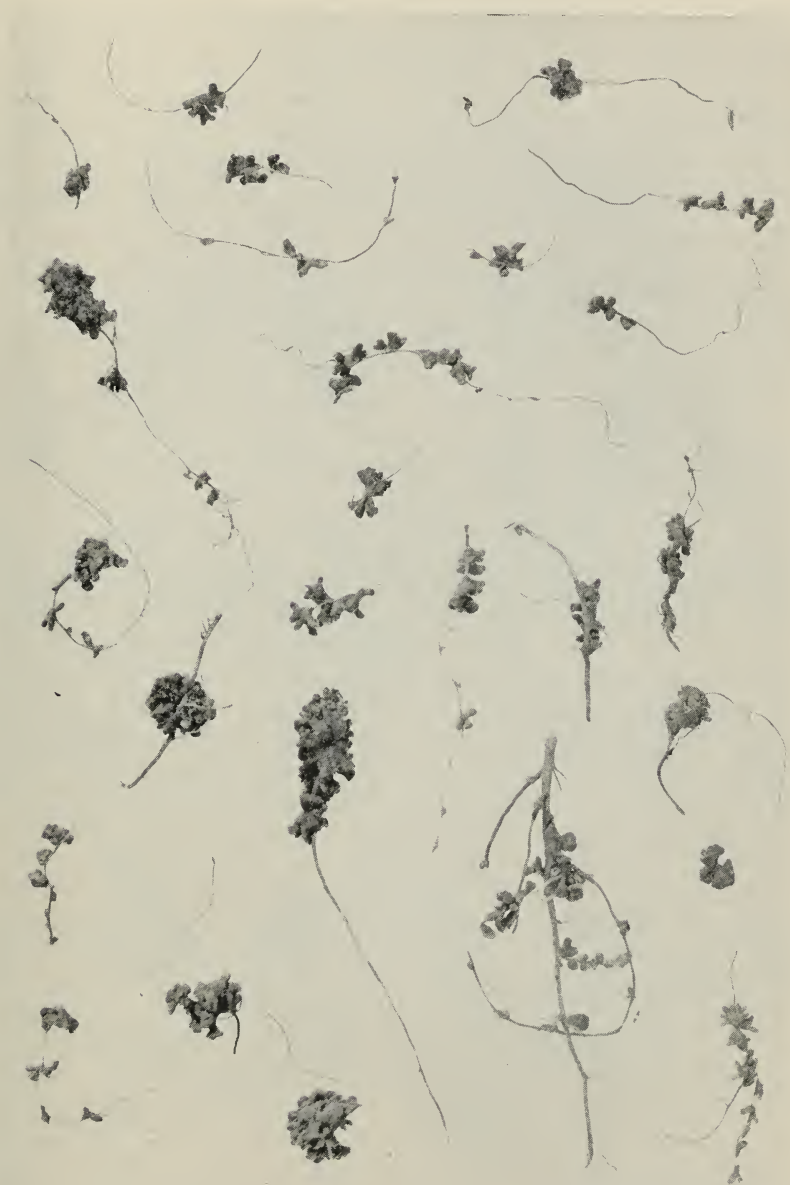
## GENERAL DESCRIPTION OF THE PLANT

Berseem, *Trifolium alexandrinum* L. is one of the true clovers belonging to the genus *Trifolium* which comprises about 300 species distributed throughout the temperate and subtropical regions of both the Old and the New World, a few being represented in tropical Africa. Taking into consideration the large number of species in the genus and its economic importance it is surprising that only a comparatively small number, about twelve, have been introduced into cultivation. The most commonly known species in cultivation are red clover, *Trifolium pratense*; Alsike Clover, *T. hybridum*; white Dutch clover, *T. repens*; and crimson clover, *T. incarnatum*.

*Trifolium alexandrinum* L., Berseem or Egyptian Clover, is an annual plant somewhat resembling red clover in its habit of growth, but with yellowish-white instead of red flowering heads. The stems



Fig. 4.—Berseem nodules. Shawver Ranch, Holtville, Imperial Valley, California.



(Natural Size)

Fig. 5.—Berseem nodules. Shawver Ranch, Holtville, Imperial Valley, California.

are hollow and very succulent. The roots (see fig. 4) do not extend far into the soil like those of alfalfa, but remain generally in the first two feet. When first grown in a new region nodules are not always found on the roots, but after one or more years they become exceedingly abundant (see fig. 5). The plant makes a dense, rank growth of from two to three feet, the number of stems increasing from the lower axils after each cutting. Frequent cutting of the crop prevents the growth of winter weeds.

The leaves are large, numerous, slightly hairy, tender and succulent, so that it is extremely palatable to stock. This succulent feature makes it necessary to exercise care when making it into hay in order to avoid discoloration and spoiling. Each leaf consists of three elliptical leaflets arranged in the trifoliate manner common to most clovers. These vary from one-half an inch to two inches in length, according to the amount of moisture or other conditions available for the growth of the plant.

Numerous yellowish-white flowers form an elliptical dense head which may vary in length from one-half an inch to one and one-half inches (see fig. 6). Each floret in the head consists of a five-lobed calyx and a corolla consisting of a standard, two wings, and the keel; the typical flower of most members of the legume family. At maturity each floret may form a box capsule containing a single seed. The seed is a little smaller than that of red clover and about the same size and shape as that of crimson clover. It is egg-shaped, reddish brown, and about one-twelfth of an inch long (2 mm.) (see fig. 7).

#### RELATIONSHIP

Gibelli and Belli<sup>9</sup> place *Trifolium alexandrinum* L. in the section *Lagopus* Koch and the group *Maritima* Nob. In this section are to be found: Our well known cultivated clovers, *Trifolium pratense* L. and *T. incarnatum* L.; the rabbit's-foot clover, *T. arvense*, is abundantly introduced and widely distributed as a weed in the eastern United States; Hungarian Clover, *T. pannonicum* Jacq., a deep-rooted long-lived perennial cultivated in Europe, known for a long time in the United States through experimental plantings, has never attained commercial status. Twelve species (12) indigenous to California belong to this section. A number of these are sufficiently abundant in many of the coast and interior valley pastures to be considered as an important source of feed. They are all annuals, the more important being *T. dichotomum* H. and A., *T. neolagopus* Loja, *T. alboburpureum* T. and G., *T. Macraei* H. and A. Another species, *T. amoenum* Greene, very limited and local in its distribution is the largest and handsomest of the indigenous species of this group. It has distinct promise as an ornamental and is possibly also worthy of introduction as supplementary forage on the ranges. Mediterranean species closely related to *T. alexandrinum* L. in the group *Maritima* Nob. are *T. maritimum* Huds., *T. echinatum* M. B., *T. dipsaceum* Thuill., and *T. obscurum* Savi.

## BOTANICAL DESCRIPTION

*Trifolium alexandrinum* L.

*Plant* annual, 1 to 3 feet, *roots* of medium size, long tapering, branched, fibrous, single or in clusters. *Stems* decumbent, ascending, sometimes with prominent transverse rings, diffuse, fistulous, glabrous at base, increasingly pilose above: *leaves* trifoliate, petiolate, petioles of the lowermost leaves very long, becoming gradually shorter above, pubescent; pseudo-opposite above: lower *stipules* oblong-ovate, upper oblong-lanceolate, ventricose, membranous-scarious, sheathed, terminating in linear-lanceolate ciliate-margined lobes:



(From Bull. 23, Bur. Pl. Ind., U.S.D.A.)

Fig. 6.—Berseem at time of blossoming.

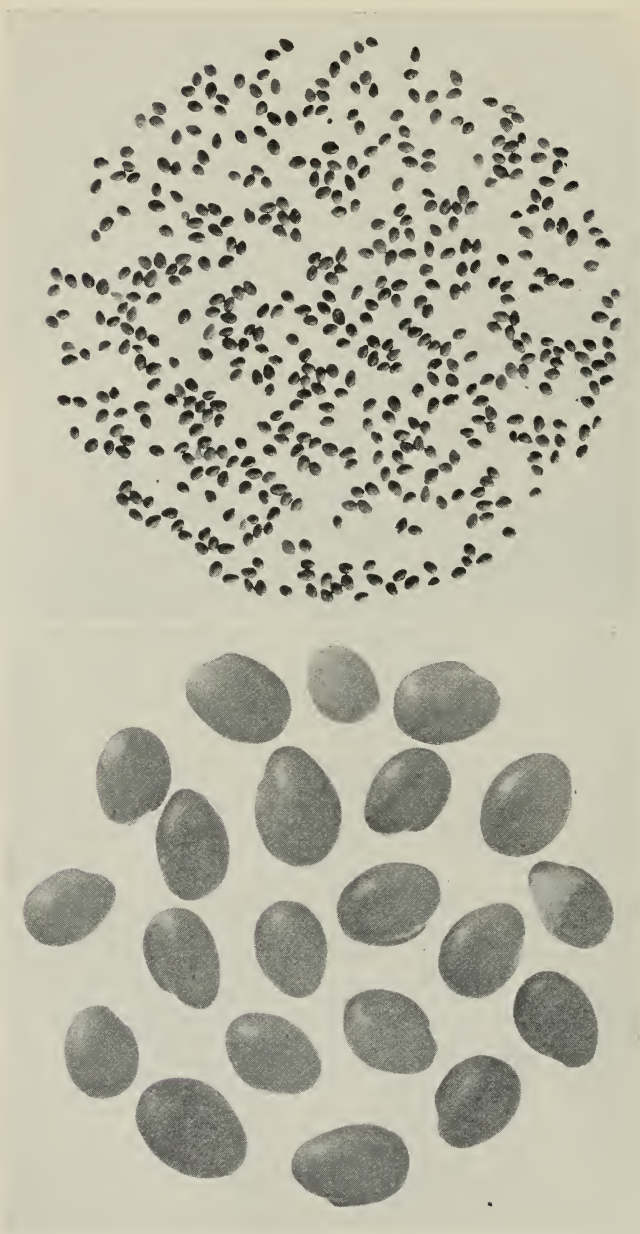


Fig. 7.—Berseem natural size (above) and  $\times 7$  (below).

*leaflets* oblong-lanceolate to oblong-elliptical, pubescent on both sides, truncate, rounded, emarginate mucronulate at the apex, margins denticulate on the upper half: *inflorescence* of dense heads terminating the stems and branches: *peduncles* short in anthesis, elongating in fruit, pubescent: *heads* pseudo-terminal, at first ovate-conical, later elliptical-conical: *florets* numerous, *calyx-tube* 3 mm. long, obconical, prominently 10-nerved, pilose, with a distinct ring of hairs but no callus at the throat, *calyx-teeth* five, triangular-subulate, about 3 mm. long, ciliate, the two superior slightly connate and almost equal to the lateral, the inferior tooth slightly exceeding the others: *corolla* ochroleucous, at least twice the length of the calyx, *vexillum* infundibuliform, with spreading limb, wings oblong semi-obovate, with numerous slender veins, auriculate at base, *keel* convex obtuse at apex, slightly lobed at base, longer than the inferior tooth: *anthers* ovate-apiculate: *ovary* sessile, obconical, one ovuled, *style* very long, slightly enlarged toward the middle, *stigma* cristate, *fruit* formed by the enlarged calyx at maturity, with the nerves of campanulate tube prominent, the throat entirely closed by the operculum of the membranous legume. *Legume* one-seeded, rarely two-seeded, the upper third consisting of an operculum firmer in texture than the lower two-thirds which is very thin and fragile: *seeds* sub-orbicular to ob-ovoid, 2 mm. long, seed coat at first dull, becoming shiny on exposure, glabrous, yellow, tinged with brown in the region of the hilum and chalaza, position of the radicle evident by a slight elevation of the seed coat, hilum orbicular, funiculus at lower third of legume.

*T. alexandrinum* var. *tuberculatum* Nob.

This variety has been regarded by Boissier as a variety of *T. supinum* Savi (*T. echinatum* M. B.) but Gibelli and Belli state that they have examined the specimen of *T. supinum* var. *tuberculatum* Boiss. in the Boissier herbarium and find that the structure of the calyx does not agree at all with that species and that it certainly belongs to *T. alexandrinum*, differing from it only by having the hairs of the calyx with large tubercles at the base and the throat of the calyx tube a little more enlarged.

*T. alexandrinum* var. *phleoides* Boiss.

Gibelli and Belli were able to study specimens of this variety in the Boissier herbarium. They conclude that it does not belong to *T. alexandrinum* but regard it as a subspecies of *T. echinatum*. They base their conclusion on differences in the head, lobes of the stipules, length of the calyx-tube and teeth, and the flowers coming off readily from the axis, but particularly in the large callus at the throat of the tube, leaving a very narrow fissure which does not occur in *T. alexandrinum*.

## VARIETIES\*

There are four distinct agricultural varieties of berseem grown in various localities and differing in rapidity of growth, number of cuttings per season, height of plant and amount and method of irrigation required. They are Miskawi, Khadrawi, Saidi and Fahl (see fig. 8).

Miskawi (Muscowi U.S.D.A.) is the variety most commonly grown in Egypt and forms the basis for the field experiments recorded in this bulletin. It is preferred in the delta region of lower Egypt where there is an abundance of water for winter irrigation but none in summer. It is a rank grower sometimes attaining a height of five feet. From

\* The writers are indebted to Mr. Y. Milad, a graduate student from Egypt for the exact English translation of the names of these varieties from the Arabic.

4 to 8 cuttings are made according to the amount of water used and the height of the crop when cut. It must be irrigated twice after each cutting. In Egypt the time of seeding is from the first of September to the middle of January. It does not do well with intense heat so that late sowings result in lessening the number of cuttings that may be made owing to injury from summer weather. When planted early and with a favorable season, the first cutting may be made in fifty days, if less favorable it may take seventy days. Normally the fifth cutting is for the production of seed. The average yield of seed in Egypt is 360 pounds to the acre.



Fig. 8.—Comparative trials of berseem varieties at Imperial Valley Experiment Station.

1. Saidi—low spreading growth, in blossom.
2. Fahl—erect growth in blossom.
3. Misgawi—heavy succulent growth, not in blossom.

Khadrawi (Kadrawi U.S.D.A.) resembles Misgawi in habit of growth but requires more water. It is said to have a longer vegetative period and heavier yield. We have not as yet grown it in California.

Saidi (Saida U.S.D.A.) is characterized by having a long root system which enables it to withstand drought. It is somewhat intermediate in growth between Misgawi and Fahl. J. A. Prescott of the Société Sultanienne D'Agriculture of Cairo writes in a letter dated December 17, 1922, that this variety is the berseem of upper Egypt, grown on the basin lands and sown in the mud after the Nile flood. It gives several cuttings (two to three) without further irrigation, and makes an excellent quality of hay. As it has a tendency to grow decumbent rather than erect, the custom of sowing it with the variety Fahl to hold it up has become established.

Fahl (Fachl U.S.D.A.) is used where water is not available after sowing and where the land is to be used immediately after cutting the

crop. The land is overflowed by the Nile during the autumn months and when the water subsides a layer of mud is deposited. The seed is sown in the mud. No further irrigation is given and only one cutting of 9 tons of green fodder is obtained.

We have obtained small quantities of the seed of these varieties from Egypt and have grown them in rod rows adjacent to one another for comparative trials. Although marked differences have been noticed in the character of growth, the main object at this time has been to obtain sufficient seed for plot trials. Excellent seed has been produced from the rod rows at the Imperial Valley Station so that we will soon be in a position to determine in what manner any of the varieties other than the Misgawi may be utilized.

Another variety which has just been brought to our attention by Professor Amram Khazanoff of the Palestine Jewish Colonization Association at Haifa, Palestine, is called Baali, or dry-land berseem. It is said to do better without irrigation than the Misgawi.

#### CLIMATE OF THE IMPERIAL VALLEY

The climate most suitable to the growing of berseem may be determined in general by a consideration of the climate of Egypt where berseem reaches its greatest perfection.

Official climatic records from the United States Department of Agriculture Weather Bureau for the Imperial Valley and from the Egyptian Ministry of Agriculture for Helwan near Cairo, are given in Table 1.

Rain is not a factor in crop production in either Egypt or Imperial Valley for less than  $2\frac{1}{2}$  inches fall annually in the Imperial and only one-third of this quantity at Cairo, Egypt, but over 8 inches at Alexandria on the Mediterranean. The relative humidity at Cairo is considerably greater than in the Imperial Valley on account, no doubt, of the proximity to the Mediterranean.

Temperature appears to be the limiting factor in the production of berseem and before successful experiments were conducted in the Imperial Valley, authorities believed the climate to be too cold for successful berseem culture. The growing season for berseem extends from September to May, inclusive. The Imperial Valley is warmer than Egypt during September and again during March, April and May, but during the months of October to February, inclusive, the climate of Egypt is warmer. The Mediterranean moderates the extremes of temperature and humidity for Egypt much more than the Gulf of California does for the Imperial Valley.

As light frosts commonly occur during the winter in both places (<sup>23</sup> p. 24), they are not considered a factor in berseem production. A lowering of the temperature which causes a severe freeze is considered to seriously affect berseem. The absolute minimum for the Imperial Valley at the critical period in mid-winter falls far below that of Egypt. The first crop of berseem grown at the Imperial Valley Experiment Station (1921-22) experienced an unusually cold winter when the thermometer reached 17 degrees F. All berseem plants were frozen to the ground (January 20, 1922) but all except those growing upon the ridges revived and by March 5 were 24 to 30 inches in height. Two crops of hay and a heavy crop of seed followed.

In late December, 1924, the thermometer registered 16 degrees F. but none of the berseem plants were killed although all were cut back to the ground by

TABLE 1

NORMAL MONTHLY, SEASONAL AND ANNUAL TEMPERATURE AND PRECIPITATION AT  
BRAWLEY, IMPERIAL VALLEY, CALIFORNIA, AND CAIRO, EGYPT  
(Records taken at Helwan Weather Observatory near Cairo)

Month	Brawley, California (Field Operations, Bureau of Soils, 1920. Brawley Area, Calif., p. 647)							Helwan, Egypt (near Cairo), 1914				
	Temperature °F.			Precipitation, inches			Relative humidity Mean	Temperature °F.			Precipitation, 1914-1915 average year	Relative humidity Mean Cairo
	Mean	Absolute maxi- mum	Absolute mini- mum	Mean	Total amount for the driest year	Total amount for the wettest year		Mean	Absolute maxi- mum	Absolute mini- mum		
December.....	52.	85	20	0.40	0.10	Tr.	30	57	68	42	.36	71.1
January.....	52.8	85	21	0.56	.00	0.90	44	56	84	39	Tr.	66.4
February.....	55.8	85	28	0.34	.00	2.02	42	57	89	40	.11	60.4
Winter.....	53.5	85	20	1.30	.10	2.92	39	57	85	39	.47	65.9
March.....	62.2	96	29	.29	.75	.00	47	60	102	49	Tr.	58.0
April.....	69.1	106	38	.04	Tr.	.00	55	70	100	55	.24	52.0
May.....	73.4	118	41	.06	.45	.15	37	66	101	58	Tr.	50.1
Spring.....	68.2	118	29	.39	1.20	.15	45	65	102	49	.24	53.3
June.....	84.2	118	51	.02	.25	.00	35	78	109	65	0	50.9
July.....	89.6	115	57	.11	Tr.	.00	33	81	103	66	0	51.8
August.....	89.2	115	60	.27	Tr.	.28	38	80	100	64	0	57.5
Summer.....	87.7	118	51	.40	.25	.28	35	80	109	64	0	53.4
September.....	83.0	111	51	.14	.00	.70	37	79	100	58	0	65.
October.....	71.2	107	40	.09	Tr.	.12	34	74	80	49	0	68.5
November.....	60.8	93	26	.15	Tr.	.00	43	64	79	41	.10	69.5
Fall.....	71.7	111	26	.38	Tr.	.82	38	72	100	41	.10	67.7
YEAR.....	70.3	118	20	2.47	1.55	4.17		68	109	39	.84	

the freeze. The Misgawi variety appeared to be the most resistant to cold damage. In June a good crop of excellent seed matured.

Ordinarily such severe cold is not experienced in the Imperial Valley the mercury seldom falling below 26 degrees or 27 degrees F. The ability of berseem to survive under these extreme conditions indicates that the climatic conditions in the Imperial Valley are not an obstacle to its successful culture. Such severe cold as that experienced in 1921-22 may, however, retard the berseem sufficiently to lose one cutting. That berseem will withstand more cold than Egyptian experience indicates, is shown by the records of Dr. Trabut Fairchild<sup>7</sup> (p. 13) at Rouiba, Algiers, when 23 degrees F was found to cause no damage. In southern Italy and Sicily, berseem must withstand even lower temperatures than in Algiers.

Early sown berseem resists frost much better than late sown.

## SOILS OF THE IMPERIAL VALLEY

The soils of the Imperial Valley are described in detail by Strahorn et al<sup>22</sup> and Kocher et al<sup>13</sup> in the Soil Survey Reports of the United States Department of Agriculture. In these reports thirty distinct soil types are described and mapped. The changes in soil texture are frequent and large bodies of soil uniform in surface and subsoil, are not usual. The soils may be grouped into hard, medium and soft. This classification closely corresponds to the value and crop producing capacity of the soils. The soils of the valley are modified considerably by the occurrence of stratified layers of sand or sandy soil in the subsoils. To the west of the Imperial Valley lie areas of sand which is blown into the valley at all times, forming dunes in places. As the prevailing winds blow from this direction, additions of sand are being constantly made. From the Colorado River to the south, overflows in the past have carried deposits of silt and clay. These sediments have been deposited over the sand causing much stratification in the subsoils. The sandy layers contribute to rise of the water table and cause surface accumulations of alkali. Silt is deposited in greatest quantities nearest the river, but the clay is carried farther away from the river into quieter waters and covers the northern part of the valley. The soils of the southern end are, therefore, more silty and softer than those of the northern end where clay largely replaces silt in the river deposits.

Experiments in the Imperial Valley with berseem indicate that tight heavy soils are not well adapted to this crop, but the softer loamy and silty soils produce good crops. At Bard in Imperial County, loose river sand deposits yielded poorly. A comparison of the texture of the soils found producing good berseem in Egypt and in the Imperial Valley is given in Table 2.

TABLE 2

TEXTURE OF SOILS PRODUCING BERSEEM IN EGYPT AND IN THE IMPERIAL VALLEY

No.	Locality	Description	Organic matter	Gravel 2 to 1 mm.	Coarse sand 1 to 0.5 mm.	Medium sand 0.5 to 0.25 mm.	Fine sand 0.25 to 0.1 mm.	Very fine sand 0.1 to 0.05 mm.	Silt 0.05 to 0.005 mm.	Clay 0.005 to 0.0001 mm.	Production of Berseem
7539	Abukir Tract.....	Loam 0-12 in.....	.50	.02	.08	.16	23.24	42.68	21.00	12.52	good
7544	Abukir Tract.....	Clay loam 0-12.....	.89	.14	.30	.18	2.32	4.14	35.08	57.44	good
7545	Abukir Tract.....	Clay loam 12-24.....	.69	.00	.10	.06	3.86	15.90	30.72	49.30	
7546	Abukir Tract.....	Clay loam 24-30.....	1.04	.00	.04	.04	.92	5.76	51.28	41.64	
7555	Kom-el-akhder..	Clay loam 0-12.....	.45	1.84	5.80	4.20	21.94	15.84	7.48	42.10	good
757018	Imperial Valley.	Imperial silty clay loam (medium).	.....	0.10	0.10	0.00	1.10	13.30	56.80	28.60	fair growth
757019	Imperial Valley.	Imperial silty clay loam (subsoil).	.....	0.00	0.10	0.10	.70	24.90	47.70	26.60	
757014	Imperial Valley.	Imperial silty clay (hard soil).	.....	0.10	0.30	0.50	4.30	14.00	44.10	36.40	poor
757015	Imperial Valley.	Imperial silty clay (subsoil).	.....	0.10	0.70	0.10	6.80	5.70	50.90	34.70	
757043	Imperial Valley.	Meloland fine sandy loam (soft soil).	.....	0.00	0.20	0.40	46.50	30.70	12.20	9.80	excellent
757044	Imperial Valley.	Meloland fine sandy loam (subsoil).	.....	0.00	0.00	0.10	17.30	26.90	35.00	20.60	

<sup>1</sup> Means [(15), p. 22.]<sup>2</sup> Strahorn [(22), pp. 27, 29, 42.]

Owing to the greater quantity of organic matter and the appearance of deep cracks in the Egyptian soils, good crops of berseem are produced on soil containing a larger percentage of clay than in soils of the Imperial Valley. In the Imperial Valley those soils containing large quantities of very fine sand or silt produce the best crops of berseem. The Imperial Valley soils which produce good crops of alfalfa, are best adapted to berseem.

## ALKALI TOLERANCE OF BERSEEM

Foaden<sup>8</sup> (p. 49) states that berseem is largely used in the reclamation of "salty" lands in Egypt and that there can be no doubt that it will grow in soils so "salty" that the majority of ordinary crops would fail. Kearney and Means<sup>11</sup> (p. 581) state that rice is first used when flood waters are applied to alkali land to wash out excess salts. Dineba or barnyard grass (*Panicum crus-galli*) a weed pest in California rice fields, is also used for the summer crop in alkali reclamation. These summer crops are followed by berseem as a winter crop, September to November. Dineba grass was entirely killed off when the alkali content varied from 0.7 to 1.4 per cent, but withstood 0.6 per cent without indications of injury. This is about the same as for alfalfa in the Imperial Valley. Berseem following rice or dineba as a winter crop was found to thrive in alkali up to 0.6 per cent. Kearney and Means<sup>11</sup> (p. 581) believe berseem to be more alkali resistant than dineba. Alkali, however, is much less injurious to plants in winter or cool weather. If the land is sufficiently free from alkali to permit a good growth of rice or dineba it is fit for berseem. Berseem is usually followed by a crop of cotton sown in the spring. If the more deeply rooted cotton shows alkali injury, this process of flooding and cropping is repeated. The composition of the alkali where berseem is grown in Egypt is quite similar to the alkali common to the Imperial Valley, as is shown in Table 3.

TABLE 3

COMPOSITION OF ALKALI IN LOWER EGYPT<sup>15</sup> AND IN IMPERIAL VALLEY CALIFORNIA<sup>10</sup>

Recombined Ions	Imperial Valley Sec. 35T. 11S R. 14E	Lower Egypt Kom-el-akhder
	<i>Per cent</i>	<i>Per cent</i>
Calcium sulphate.....	11.06	10.43
Magnesium sulphate.....	13.58	9.90
Potassium chloride.....	3.93	3.62
Sodium chloride.....	53.78	60.88
Sodium bicarbonate.....	4.89	1.41
Sodium sulphate.....	12.76	13.76
Total soluble salts in first foot of soil.....	2.70	8.20

According to these analyses a remarkable similarity is at once apparent. In both Egypt and Imperial Valley large quantities of gypsum (calcium sulphate) render the occurrence of black alkali (sodium carbonate) unlikely, except under unusual conditions. Considerably more than half the alkali in each analysis consists of common salt (sodium chloride) which is readily leached out.

## RESULTS OF EXPERIMENTS WITH BERSEEM IN CALIFORNIA

*Early Experiments.*—The first record we can find of the growing of berseem in California is in 1896 when some seed was received from the United States Department of Agriculture by the Agricultural Experiment Station at Berkeley. The note states that it was not a success at Berkeley and that it was being sent to the substations at Tulare and Pomona in the hope of getting better results. No accession numbers appear with these records. Seed and Plant Introduction numbers of the U.S.D.A. 4254, 4255 and 4256 show that three varieties of berseem were received through Messrs. Lathrop and Fairchild from Cairo, December 28, 1899. These were forwarded to the Experiment Station at Berkeley and sown at the Southern Coast Range Substation near Paso Robles, December 21, 1900. The results were unfavorable because of spring frosts and cold. S.P.I. No. 7031 was received from the U.S.D.A. about October 23, 1901. It was the variety "Muscowi" and the shipment consisted of two and one-half bushels of seed. S.P.I. No. 7657 "Saida"; No. 7658 "Fachl" and No. 7659 "Muscowi" were received from the U.S.D.A. on November 25, 1901. This shipment enabled the Experiment Station to distribute lots of from 1 to 50 pounds each for trial at the substations, as well as to numerous individual coöperators. In addition a considerable number of lots were sent directly from Washington, D. C. to farmers. In the autumn of 1904 S.P.I. Nos. 9874 "Muscowi," 9875 "Fachl" and 9876 "Saida" were received from the U.S.D.A. and were distributed as follows on September 8, 1904: Twenty pounds of each to Bernard G. Johnson, U.S.D.A. date garden, at Mecca; ten pounds of "Muscowi" and five pounds of "Saida" and "Fachl" to J. W. Mills to be grown on the "Home Tract" of the Southern California substation in Chino Valley. These experiments were conducted under the direction of the late Professor A. V. Stubenrauch in connection with green manure studies. The report from Johnson shows that the variety "Muscowi" was the most vigorous grower, producing two cuttings 18 inches high before being plowed under on March 5. The crop was not considered promising mainly on account of the ground becoming white with alkali and the lack of water to keep it down. Mills reports that he planted the seed September 22, 1904 and obtained a good stand. It grew 12 inches in height by March 15, when it was plowed under. No difference is mentioned between the varieties, except that "Muscowi" was 4 inches taller.

Twenty pounds of S.P.I. 10373 "Muscowi" was received from the U.S.D.A. 1905 and distributed to five experimenters. No report is in the files as to their success or failure.

The published and unpublished reports were generally not favorable but many factors contributed to the poor results. Scarcity of water for irrigation, too late sowing, too cold winters, weeds, alkali, severe frosts, lack of inoculation, and a general lack of knowledge of the cultural requirements of the plant.

With the abandonment of the substations the earlier experiments with berseem were discontinued. The names prominently associated with these preliminary trials are A. V. Stubenrauch, J. B. Davy, C. H. Shinn, E. Kellner, J. W. Mills and B. G. Johnson.

*More Recent Experiments.*—The trials with berseem were continued at the Government Trial Grounds of the United States Department of Agriculture at Chico with generally poor results until 1916. In subsequent years a marked improvement in its growth was observed. No satisfactory explanation can be given for this except the accumulation of suitable inoculation material in the soil.

The first successful planting of berseem in California was in the autumn of 1918 when seed inoculated with soil from Chico was sown in rod rows by H. L. Westover at the Experiment Station at Bard in the Imperial Valley on land controlled by the Office of Western Irrigation Agriculture, Bureau of Plant Industry, U.S.D.A., Washington, D. C. A heavy growth was obtained and seed saved by H. R. Reed which resulted in a half-acre trial in 1919. The crop continued to improve in subsequent years, as inoculation increased.

In September, 1921, inoculated seed was sent from Bard to L. G. Goar, Superintendent, University of California Branch Experiment Station at El Centro in accordance with arrangements made by R. McKee with P. B. Kennedy. Good results were obtained from this planting. A small commercial planting was arranged for near Bard by E. S. Noble, Superintendent at Bard, and a good crop of seed produced in 1922. The experiments are now being conducted by the writers in coöperation with the Experiment Station at Bard and the County Agent of Imperial Valley, E. L. Garthwaite.

#### CULTURAL METHODS

In the preparation of the soil for berseem, the land should be leveled and the seed bed smoothed and fined as for alfalfa. The border or strip method of irrigation is preferred. The light textured soils present no difficulties when the soil is irrigated to sprout the seed, but

on the heavy soils not so well adapted to berseem, the stand and subsequent growth is much improved by corrugating the surface in the direction of the flowing water. In this manner the whole of the soil is sub-irrigated or saturated by capillarity, avoiding the detrimental effects of flooding. As these corrugations are only 4 or 5 inches high, they offer no obstacle to the mower.

*Seeding.*—In Egypt 60 to 80 pounds of seed to the acre is sown broadcast, usually in the mud. The berseem sown on medium soil at the Imperial Valley Experiment Station and on farms on softer soils in the region, produced excellent stands from drilling 12 pounds to the acre. On heavy or poorly conditioned soils, as much as 20 pounds to the acre should be sown. Larger quantities of seed produce too thick a stand which prevents tillering and spreading of the root crowns. In the softer soils, the minimum quantity of 12 pounds to the acre is preferred. The Imperial Valley seed gave a much higher germination than the Egyptian seed. Weevil attacks, usually lower the viability of the Egyptian seed from 10 to 20 per cent. At present no weevils are found attacking the California grown seed. "Blasting," or shriveling of the endosperm and germ which is common in Egyptian seed causes little damage in Imperial Valley.

Berseem may be seeded in August but October is the preferred time in Egypt because early sown berseem is usually destroyed by caterpillars. In the Imperial Valley, experiments proved that late September or early October were preferable times of seeding. Early sown berseem becomes well established before cool weather sets in. A crop may be matured from early sown berseem in 50 days from seeding while late sown, November to December, may require 70 to 90 days to produce the first crop. The frosts of midwinter are not so severe on early sown well grown plants, but young plants in late seeding may be killed by the heaviest frosts. When a crop of seed only is desired, spring seeding in February may be practiced.

*Irrigation.*—Water is applied to the berseem sown in dry ground and the berseem "irrigated up." If the water carries its heaviest load of silt as it sometimes does when the Gila River is in flood, serious smothering of very young berseem seedlings may result. Berseem requires almost the same quantity of water as alfalfa applied in the same manner and at the same intervals of time. Too frequent irrigations were found to retard the development of roots and stems. The production of plots similarly prepared and seeded was the same in all respects, whether irrigated 7, 14, 21 or 28 days apart until March 15, after which two irrigations per crop period of 30 days were given. Softer soils require fewer irrigations.

*Harvesting and Yields.*—The best growth with berseem is secured by mowing the first crop when the plants are about 9 inches high. This early clipping causes new shoots to start quickly. For early sown berseem this cutting should be made about the first of January. About 40 or 50 days later the second crop may be cut. If no seed is to be produced three more crops may be harvested by June 1st when the hot weather usually terminates its growing period. When seed is desired, the fourth or last crop is allowed to mature. It should be ready to cut after the first week in June.



Fig. 9A.—Second crop of berseem from seed sown October 5, 1923, on hard soil. Imperial Valley Experiment Station, February 19, 1924.

When berseem is grown on soft soil under favorable conditions, it should be cut every 30 days after about the first of February at which time it should be about 24 inches in height. Before the crop is cut the following crop is already sending up shoots.

Berseem contains more water than alfalfa, dries more slowly and matures at the season when the conditions for quick curing of hay are unfavorable. The best results in Egypt and Imperial are obtained when the berseem is hauled from the field as soon as cut, and fed green to dairy stock.

Berseem hay is very brittle when cured and is not so attractive in appearance as alfalfa hay. It has not been satisfactory for sale in the market because of its tendency to break and pulverize when baled. It is however a very excellent feed and preferred by all kinds of stock to alfalfa.

On the heavy infertile soil of the Imperial Valley Experiment Station, berseem yielded 10 to 12 tons of green fodder to the acre in addition to a crop of seed. Soft soil near El Centro produced in four crops of berseem  $23\frac{1}{2}$  tons of green feed to the acre by April 16, after which a seed crop of 792 pounds to the acre was harvested (see fig. 10).

In Egypt where berseem has long been grown and its culture thoroughly understood, yields as high as 42 tons to the acre are reported, Fairchild.<sup>7</sup> It seems reasonable to assume that as berseem becomes better known and the methods of handling the soil and crop



Fig. 9B.—Berseem crop on soft soil (half grown). Hoppin Ranch, near El Centro, Imperial Valley, California.

improve, that yields approaching that of Egypt will be obtained in the Imperial Valley.

*Seed Production.*—Seed sets abundantly and is of good quality. Unlike alfalfa, the most vigorous berseem produces the best and heaviest crops of seed.

The alfalfa huller or thresher is preferred, but any well regulated grain thresher will easily remove the seed from the soft pods. The straw from the threshing is itself excellent feed and practically as valuable as berseem hay.

One field of soft soil in the Imperial Valley produced seed at the rate of 792 pounds to the acre, but less than half of this amount was secured from the heavy soils of the Experiment Station.

Seed may be obtained commercially in Imperial Valley, Australia and Egypt.

## FEEDING VALUE OF BERSEEM

All kinds of stock and poultry relish berseem and prefer it to alfalfa. In fields of alfalfa and berseem mixed, cattle and horses select the berseem, leaving most of the alfalfa until the berseem has been grazed to the ground. As a soiling crop fed green to dairy cows, it has no equal. Near Brawley a dairyman pasturing his cows on excellent alfalfa, changed to berseem with the following results:



Fig. 10.—Berseem on soft soil, 21 days after cutting. Hoppin Ranch, El Centro, Imperial Valley, California.

TABLE 4

EFFECT OF BERSEEM ON PRODUCTION OF BUTTER FAT WITH THREE COWS TAKEN FROM ALFALFA PASTURE

	Pounds butter fat per day
Alfalfa (green), average butter fat per day, Feb. 18-21.....	4.29
Berseem (after feeding green 2 days), Feb. 23.....	4.42
Berseem (after feeding green 6 days), Feb. 26.....	4.96
Berseem (after feeding green 7 days), Feb. 27.....	4.72
Berseem (after feeding green 8 days), Feb. 28.....	4.80

This increase in butter fat per cow daily due to replacing alfalfa with berseem was more than 10 per cent.

*Chemical Analyses of Berseem and Alfalfa.*—Berseem and alfalfa from the Imperial Valley were analyzed and the results included in Table 5.

TABLE 5  
CHEMICAL ANALYSES<sup>1</sup> OF BERSEEM (MISGAWI) AND ALFALFA

	Berseem						Alfalfa		
	First cutting			Second cutting			Fresh (green) calculated (Fairchild, p. 16)	Air dry	Water free
	Fresh	Air dry	Water free	Green (fresh)	Air dry	Water free			
	%	%	%	%	%	%	%	%	%
Moisture.....	81.50	9.50	.....	81.50	8.77	.....	75.00	11.96	.....
Protein.....	1.90	9.29	10.27	3.17	15.63	17.65	3.47	12.21	13.87
Fat.....	.49	2.39	2.65	.74	3.65	4.00	.32	1.13	1.28
Ash.....	3.00	14.67	16.22	2.80	13.80	15.15	2.16	7.62	8.66
Crude fiber.....	3.71	18.14	20.05	3.92	19.34	21.20	9.33	32.86	37.32
Carbohydrates.....	9.40	46.01	50.81	7.87	38.81	42.00	9.72	34.22	38.87
Lime (CaO).....	.76	3.71	.....	.57	2.83	.....	.....	.....	.....

<sup>1</sup> Analyses of berseem by Harold Goss, Division of Nutrition, California Agricultural Experiment Station.

Some striking differences at once become apparent and serve perhaps to explain the evident superiority of berseem in fattening stock and in milk production. Berseem is more succulent, for in the fresh state it contains more water and little more than half the quantity of crude fiber found in alfalfa. Considerable more than twice as much fat and appreciably more carbohydrate occur in berseem. The second cutting of berseem contains more protein and the first cutting less protein than alfalfa. The total protein content is apparently about the same in both forages. Berseem contains almost twice as much ash as alfalfa, but the proportion of lime (CaO) in the ash is approximately the same (20 to 25 per cent). For dairy cows which draw heavily upon stored lime in their bodies during the lactation period the presence of such large quantities of available lime is decidedly favorable.

In Egypt cattle are tethered in long lines abreast in fields of berseem and in this manner regularly harvest the crop. Labor costs would prohibit this method in California unless the cows could be watered by wagon when milked. Berseem does not give the butter or milk any unusual flavor.

## BLOATING

Bloating (tympanitis) from feeding berseem when covered with dew is very rare in Egypt (Foaden,<sup>8</sup> p. 48) and Australia (Bunning,<sup>4</sup> p. 92) and not serious when it does occur. In the Imperial Valley no bloating with berseem has occurred, although it is reported for alfalfa.

## BERSEEM IN CROP ROTATIONS

Berseem occupies annually more than 29 per cent (Willcocks and Craig,<sup>23</sup> p. 770) of the total tilled lands of Egypt calculating the lands cropped twice a year as double acreage. By using berseem as a winter crop in connection with rotations of summer crops of cotton, maize and rice over 45 per cent of the agricultural area is double cropped each year. The price of cotton may at times vary these proportions in either direction. It is the principal feed for all stock but its main use in Egyptian agriculture lies in its value as a rotation crop in maintaining crop production in rotations with cotton, maize and grain. Cotton in particular depends upon berseem in the rotation for both the quality and quantity of fiber produced.

In Egypt, according to Prescott,<sup>20</sup> two general plans of rotation are practiced.

*Plan A.—*

Berseem	October to May
Maize ( <i>Zea</i> )	July to November
Cotton	March to October
Wheat	November to May
Berseem	October to May, etc.

This plan provides ample time after the wheat harvest in May (as in Imperial) to prepare for early seeding of berseem. Sufficient time occurs after the maize harvest to prepare the land for cotton, but less time is available for seeding wheat after cotton.

*Plan B.—*

Cotton	March to October
Berseem	November to May
Maize	July to October
Wheat	November to May
Maize	July to November
Cotton	as above

This rotation is the more common and is used to supply nitrogen to the cereal crops. In addition to this, berseem is often sown in stand-

ing cotton or maize in the fall as a catch crop to be pastured lightly and then plowed under early. Better yields result when cotton and maize stalks are removed and the land plowed and well prepared before the berseem is sown. This rotation furnishes the cotton with nitrogen. A difference from 10 to 20 bushels per acre in favor of berseem is noted in the maize crop when wheat or berseem precede it. Cotton in Egypt does not respond well to chemical fertilizers.

*Comparison with Alfalfa.*—Naturally any leguminous forage plant coming into use as a feed for dairy and other stock will be compared with alfalfa. Berseem and alfalfa resemble each other in drought and alkali tolerance, repeated croppings from the same plants under irrigation, high production of palatable and nutritious feed, both green and cured, and high value as green manure in crop rotations.

Points of dissimilarity like growth period and persistence place them in separate fields of usefulness. Alfalfa, a perennial, requires from one to two seasons to become thoroughly established at maximum production, while berseem an annual, produces its crops mainly through the winter and spring of a single crop year. It can be plowed under at any time during the period of its growth and quickly incorporated into the soil to the immediate advantage of the crops which follow in rotation. Alfalfa fosters insect pests of cotton and other crops in summer. The culture of alfalfa is forbidden by law in Egypt (Prescott<sup>20</sup>) because it harbors the cutworm (*Agrotis ypsilon*) and draws heavily upon summer water which is scarce. Alfalfa occupies the land over too long a period to the exclusion of cash crops like cotton and truck crops, which give greater returns to the acre. Berseem on the contrary makes possible double cropping with crops like cotton and lettuce, without the three or four-year wait, when alfalfa is used in the rotation.

Alfalfa in rotation with truck and cotton crops in the Imperial Valley occurs in the following order. Old alfalfa (three or more years) becomes thin, foul with weeds, and drowned out in spots or irrigates poorly because of deposits of silt. The alfalfa land is rented to a truck grower usually for three years. Cantaloupes may first occupy the land and be followed by fall planted lettuce or either crop may occupy the land for two or three years. The soil rapidly loses its productivity for these truck crops and the final crop may be cotton or grain sorghum which leaves the land in a very poor condition when the renter returns it to the owner at the end of his lease. The owner must now proceed to relevel and recheck the land. This practice usually loses him one year before he can again reseed it to alfalfa.

After another three or four year period he will again be ready to lease for cash. The alfalfa returns are usually far less than those for truck or cotton crops.

*Berseem in Relation to Cotton and Sorghum.*—On the softer silty soils, especially in that part of the Imperial Valley lying in Mexico, cotton is a great cash crop. Cotton land is mainly farmed by renters who continue to grow cotton year after year for several years. Frequently the old but living cotton stalks are cut off and a sucker crop grown from the old roots. The result is a steady deterioration in yield.

We might follow the successful practice of rotation in Egypt and sow berseem in the standing cotton or sorghum in October with irrigation. These crops in very dry regions are not injuriously affected by late irrigations. The injurious after effect of sorghums will be reduced by the following crop of berseem. In Egypt the early sown berseem crop is ready for pasturing in January, and until it is ready to be plowed under previous to the seeding of cotton in March. If the berseem is to be pastured, the Misgawi variety is preferred because it pastures well and comes up repeatedly from the root crown. When the whole berseem crop is plowed under, the Fahl and Saidi varieties may be preferred because these varieties produce a larger first crop than Misgawi. Mackenzie (Foaden,<sup>8</sup> p. 48) has shown that considerable nitrogen is added to the soil during the early growth of berseem but little or none by the late growth:

Nitrogen in soil before sowing berseem .....	0.099	0.101
Nitrogen in soil after the first cutting .....	0.110	0.116
Nitrogen in soil after the second cutting .....	0.113	0.111
Nitrogen in soil after the third cutting .....	0.105	.....
Nitrogen in soil after the fourth cutting .....	0.099	.....

After two cuttings of berseem approximately 300 pounds of nitrogen to the acre have been added. Sixty or seventy pounds to the acre of this organic nitrogen is considered sufficient for a good crop. Berseem roots and straw rapidly become converted into organic matter when cultivated into the soil. Alfalfa roots, on the contrary, persist and many plants renew their growth much to the annoyance of the farmer when truck crops are grown.

*Inoculation.*—The root system of berseem is shallow but carries with it large quantities of nodules. At Bard and Meloland in Imperial County where berseem was first grown, no nodules appeared in the roots the first year (see fig. 11). The plants were yellowish green in appearance and not very thrifty. Without inoculation of any kind an abundance of nodules appeared in the same land the second year.

Seed from the first crop produced at Meloland when sown in other parts of the valley where berseem had not previously been grown, gave rise to plants abundantly supplied with nodules. A dark green color accompanied the nodule bearing plants, contrasting favorably with the yellowish color of the berseem plants without nodules. It appears that the strain of nodule forming bacteria necessary for inoculating berseem is common in the Imperial Valley.



Fig. 11.—Berseem seed crop. Bard, Imperial County, California. (No nodules were found in this crop, but abundant nodules appeared in the next year's crop.)

*Seeding Berseem in Alfalfa.*—Experiments with seeding berseem in old alfalfa to secure a better production of pasturage in winter were not very successful because of the compact condition of the soil. Berseem must have a deep, loose, well tilled seed bed. The Misgawi variety is best for sowing into alfalfa because it pastures well.

*Seeding Berseem in Barley.*—Seeding berseem into barley fields, especially where barley is to be pastured in the early stages, promises better success if the barley is not sown too thickly. Berseem should be sown early and after pasturing may be allowed to mature and produce seed with the barley. The barley may then be recleaned and the berseem seed recovered. For seeding with barley or other cereals the Fahl or Saidi varieties are best because they normally produce only one cutting.

## BERSEEM AND WEEDS

When berseem is sown early on soft soil ordinary weeds are controlled by its dense growth, but when grown on hard soils or when the stand is thin, weeds may continue. Mallow (*Malva*) and Lamb's-quarters (*Chenopodium* sp.) have persisted in berseem fields in the Imperial Valley.

Melilotus (*M. indica*) has become established in the Imperial Valley and is persistent in fields of berseem on heavy or hard soils. Mixed seed of both clover and berseem are almost impossible to separate. Contaminated berseem fields should not be harvested for seed.

Dodder (*Cuscuta*) attacks berseem in Egypt, but has not as yet appeared on berseem in California.

## PESTS

No berseem fungous pests are known. Insect pests, however, are numerous and many species highly injurious to other crops are attracted to berseem where they multiply enormously. As these insects increase during the summer, irrigation of berseem in Egypt is stopped by law by the end of April.

Nematodes attack truck crops in the Imperial Valley and many legume crops as well. For this reason many excellent green manure crops like mung beans, cowpeas, vetches, sesbania and pea crops are objectionable because nematodes are carried over in abundance to the succeeding truck crops. Berseem has shown nematode attack (Malloch<sup>14</sup>) in the Imperial Valley, but like alfalfa it carries nematodes (Bessey<sup>2</sup>) in limited numbers.

Weevils which attack berseem severely in Egypt have not yet appeared in the Imperial Valley. The Chalcis fly, found attacking alfalfa seed in this region has not attacked berseem.

## SUMMARY

Berseem from the results of the preliminary trials gives much promise for forage and green manure as a new crop for the Imperial Valley. It is an annual leguminous plant which may be cut several times in one season. Future investigations with cold-tolerant and dry-land varieties may extend the area in which berseem may be grown to other sections of the state.

The variety Misgawi, now grown, is best adapted to regions of mild winters where irrigation is practiced.

The plant is alkali tolerant to a considerable degree.

As green fodder or as hay it has been found more palatable and nutritious than alfalfa.

The stems are succulent and the roots are covered with numerous nitrogen-bearing nodules. This makes it an ideal plant to turn under as green manure.

It may be found valuable in a rotation with such crops as sorghum, cotton, lettuce and cantaloupes.

The crop is easily seeded, grown and harvested.

It has an ameliorating effect upon the soil and increases the yields of other succeeding crops.

Seed of good quality can be produced in the Imperial Valley.

## LITERATURE CITED

- <sup>1</sup> AARONSOHN, A.  
1910. Agricultural and botanical explorations in Palestine. U. S. Dept. Agr., Bur. Pl. Ind. Bull. 180:28.
- <sup>2</sup> BESSEY, EARNEST A.  
1911. Root-knot and its control. U. S. Dept. Agr., Bur. Pl. Ind. Bull. 217:1-89, pls. 1-3.
- <sup>3</sup> BOISSIER, E. F.  
1872. *Flora orientalis*. 2:127.
- <sup>4</sup> BRUNNING, LESLIE H.  
1922. Fodder crops for Australia. 85-94.
- <sup>5</sup> DECANDOLLE, A.  
1886. Origin of cultivated plants. p. 107, American edition.
- <sup>6</sup> DE CILLIS, E.  
1911. Una nuova foragera per i paesi caldi. Rev. Agr. 21:45-72.  
(Extract Int. Ins. Agr. 3:570.)
- <sup>7</sup> FAIRCHILD, DAVID G.  
1902. Berseem: The great forage and soiling crop of the Nile Valley, Egypt. U. S. Dept. Agr., Bur. Pl. Ind. Bull. 23:1-20, pls. 1-14.

- <sup>8</sup> FOADEN, GEORGE P.  
1904. Egyptian Agriculture. U. S. Dept. Agr., Bur. Pl. Ind. Bull. 62:1-61, pls. 1-6, figs. 1-12.
- <sup>9</sup> GIBELLI, G., AND BELLI, S.  
1889. Rivista critica e descrittiva delle specie de Trifolium Italiane. Mem. Reale Accad. Sci. Torino. II 39:148.
- <sup>10</sup> HOLMES, J. GARNETT, ET AL.  
1903. Soil survey of the Imperial Area, California. (Extending survey of 1901). Field operations, U. S. Dept. Agr., Bur. Soils, 1219-1248.
- <sup>11</sup> KEARNEY, THOMAS H., AND MEANS, THOMAS H.  
1902. Crops used in the reclamation of alkali lands in Egypt. U. S. Dept. Agr. Yearbook, pp. 573-588, pls. 1-4, fig. 1.
- <sup>12</sup> KENNEDY, P. B.  
1913. Studies in Trifolium—VII. Muhlenbergia. 9:1-29, pls. 1-4.
- <sup>13</sup> KOCHER, H. E., ET AL.  
1923. Soil survey of the Brawley Area, California. Advance sheets. Field operations, U. S. Dept. Agr., Bur. Soils, 1920, pp. 661-700.
- <sup>14</sup> MALLOCH, W. S.  
1923. The problem of breeding nematode resistant plants. Phytopathology, 13:443.
- <sup>15</sup> MEANS, THOMAS H.  
1903. Reclamation of alkali lands in Egypt as adopted to similar work in the United States. U. S. Dept. Agr., Bur. Soils, Bull. 21:1-48, pls. 1-8, figs. 1-6.
- <sup>16</sup> MUSCHLER, R.  
1912. A manual flora of Egypt. 1:497.
- <sup>17</sup> PIPER, C. V.  
1924. Forage plants and their culture. (Revised edition) p. 461.
- <sup>18</sup> PIPER, C. V.  
1907. Leguminous crops for green manuring. U. S. Dept. Agr. Farmers' Bull. 278:27.
- <sup>19</sup> PIPER, C. V., AND PIETERS, A. J.  
1922. Green manuring. U. S. Dept. Agr. Farmers' Bull. 1250:1-42.
- <sup>20</sup> PRESCOTT, J. A.  
1922. Société Sultanienne d'Agriculture, Cairo, Egypt. (Letter dated Dec. 17.)
- <sup>21</sup> SORNAY, P. DE  
1916. Green manures and green manuring in the tropics. p. 289.
- <sup>22</sup> STRAHORN, A. T., ET AL.  
1922. Soil survey of the El Centro Area, California. Advance sheets. Field operations, U. S. Dept. Agr., Bur. Soils, 1918, pp. 18-47.
- <sup>23</sup> WILLCOCKS, SIR W., AND CRAIG, J. I.  
1918. Egyptian irrigation. Third ed., pp. 1-884, pls. 1-8, figs. 1-188.